EMS Annual Meeting Abstracts
Vol. 14, EMS2017-134, 2017

Analysis of a winter storm using PV-inversion techniques

Michael Langguth and Andreas Bott
Meteorological Institute of the University of Bonn, Bonn, Germany (mlangguth@uni-bonn.de)

Despite continuous improvements of numerical weather prediction (NWP) models in the last decades, the correct forecast of severe winter storm events in midlatitudes is still a challenging task. Thus, a detailed process-understanding of atmospheric conditions leading to the formation of these strong low pressure systems is crucial for the meteorological society.

One approach to explain thermodynamic processes in the atmosphere is to consider the spatio-temporal evolution of Potential Vorticity (PV) patterns. This strategy even allows for quantification of the impact of certain anomalies by making use of PV-inversion techniques.

The aim of this study is to couple a PV-inversion tool with the mesoscale NWP model COSMO developed by the German Meteorological Service (DWD) and to analyze the development of a severe winter storm affecting Western Europe in December 2013.

While the COSMO model is able to represent mesoscale processes, the PV-inversion tool is based on assumptions which are restricted to synoptic scales. On top of that, the PV-inversion tool makes use of a pressure-based vertical coordinate which can be problematic when analyzing processes in the vicinity of elevated topography such as Greenland. The developed coupling tool takes into account both, the scale difficulty and the problem of isobaric pressure levels crossing the surface. In order to enable PV-inversion in the North Atlantic where many midlatitude lows form and where the surface of the Greenland ice sheet reaches up to the 700 hPa-layer, a new extrapolation strategy is used to obtain required data on pressure levels below the surface. This created data set proves to be well balanced in the study area, which implies that the inversion process is more robust and more applicable for so-called piecewise PV-inversion accessing the importance of specified PV-anomalies.

By applying the coupling tool, the formation processes of the severe winter storm mentioned above are investigated. Classifying different PV anomalies and analyzing their impact by piecewise PV inversion techniques show, that the initial phase is controlled by a diabatic Rossby wave accompanied with warm and moist air in the lower troposphere. Several hours later, the interaction with an upper-level trough and a persistent lee low, induced by a katabatic flow towards the Irminger Sea, leads to atmospheric conditions enabling rapid intensification of the cyclone. Finally, the intense cyclone approaches a mature trough system which leads to another short intensification period before the vertical axis of the anomalies tilts up and the intensification process is stopped.

The presented results show the benefit of analyzing atmospheric processes within the PV-framework in combination with a mesoscale model.